When Zulus cannot smile, they frown,
To keep an arc before the eye.
Describing distances to town,
They say, "As flies the butterfly."

Abstract

This article provides samples of traditional scientific knowledge in Burundi and Rwanda:

- as an introduction, considerations on the traditional architecture;
- conceptions of the sky and ways of counting the phases of the moon using bits of strings;
- words in the traditional tongue for numbers up to 1,999,999,999.

This information might give another view on the region of Burundi and Rwanda, today unfortunately too well known because of its climate of unrest and violence.

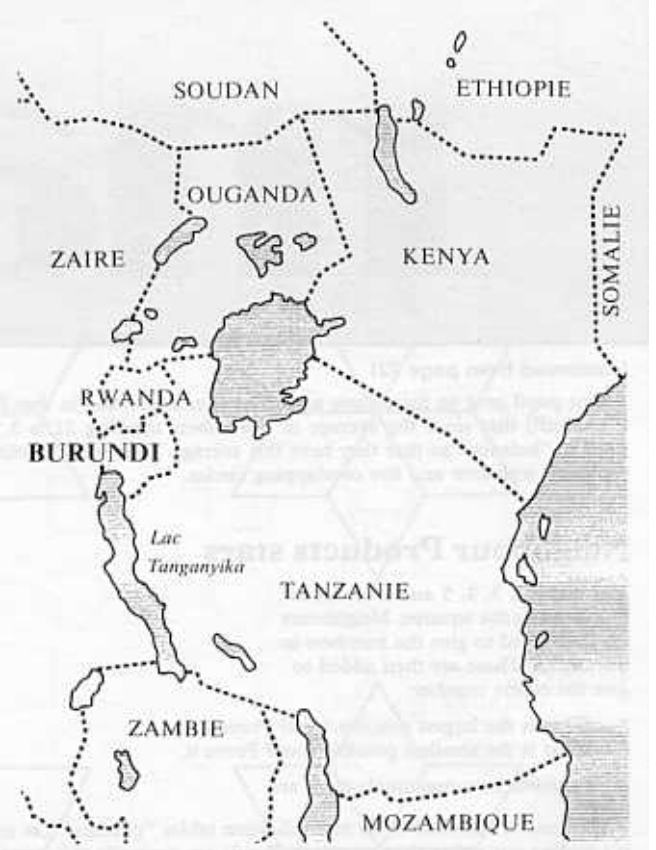


Fig. 1 Map of eastern Africa

Traditional Scientific Knowledge in Burundi and Rwanda

by D. Huylebrouck,
Ostende, Belgium.

Introduction

Burundi and Rwanda are two small countries in the middle of Africa, surrounded by Zaire, Tanzania and Uganda. There are many similarities between their populations, languages and cultures. Some pretend that, with respect to Rwanda, *(B)urundi* would simply mean *the other [country]*. Almost round hills form most parts of the two countries. On their tops and flanks, one of the most dense populations of Africa lives from agriculture and cattle breeding. The architectural similarities provide another evidence of the cultural unity. Following Acquier [1986], an architectural stereotype has imposed itself through times: the *rugo*, meaning *many huts*. It is a partition for cattle together with the habitations of the parents and the children. Circles dominate the plan of a *rugo*. The walls of the huts and the fences are circular too.

However, in the areas close to the borders with other countries, modifications exist. Elsewhere other types of architecture might dominate for local reasons. It is also interesting to remark the evolution in time. In Acquier [1986] this is represented by several drawings. Fig. 3a corresponds to the period before 1920; it is the typical

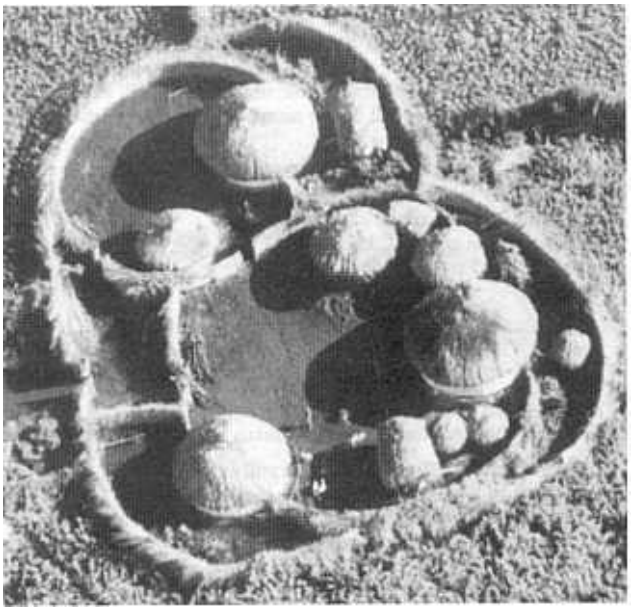


Fig. 2 Traditional rugo

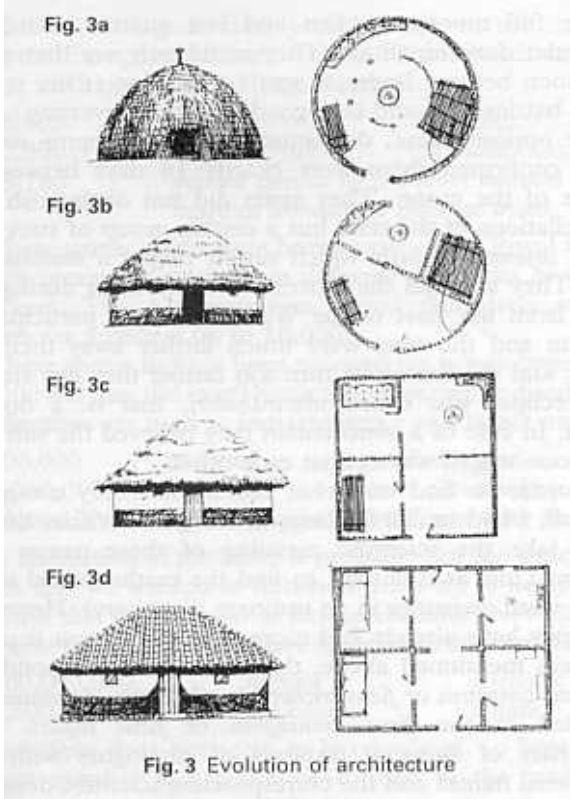


Fig. 3 Evolution of architecture

archaic hut or *igisenge*, entirely made of vegetation, constructed around the center, the hearth. Some minor changes can be noticed until 1940 (fig. 3b) when other materials are introduced. Then, the plan becomes square and the hearth loses its central place (fig. 3c). Finally in 1945–1950, (fig. 3d), a more European disposition was adapted. Nevertheless, the traditional round *rugos* are still widely spread (but their number decreases), as a tourist will admire when flying over the hills (see fig 2).

Martin Gardner too found it very puzzling that in some parts of Africa traditions indicated an entirely round conception of the world. Speaking about the Zulu tribe in Southern Africa, he wondered that their houses and doors were round, the work on the field being done along curves instead of following straight lines. He illustrated these findings by a few lines from a poem of John Updike: *Zulus Live in a Land Without a Square*. Studies would have shown optical illusions with parallel lines crossed by other lines are not conceived by the Zulus as they are by Europeans. Clearly, the architectural studies quoted above suggest a similar conception of a curved universe in the region of Burundi as well. It would be interesting to check student's visions of two and three dimensional images to improve teaching of the subject in this country, or at least to register an eventually different conception of the universe, before it is lost, like the traditional round *rugo* structure.

Note that the Burundi and Zulu cultures did indeed meet. A branch of the Zulu army reached the border of the Burundi kingdom and was beaten in 1854.

Conceptions of the Universe

I taught the *Special Methodology for Mathematics Teachers* course, for several years, at the University of Burundi. I defended the study of non European roots of mathematics by the future mathematics teachers who had to follow this course (Nelson et al, 1963). On their curriculum were, for example, number registration methods used by the Incas. During the explanation of this *American* method of using bits of strings for counting, a student suggested similar traditions existed in Burundi. Indeed, historians at the university confirmed having heard about it, but I was interested to have more detailed and firsthand information about what seemed to be known in general. I went to the student's village at his parents *rugo* (cf. fig. 4; for the sake of authenticity, the village is called *Kibago*, and is situated near a more important city, *Makamba*, in the south of the country, near to the border with Tanzania). There, we had a little inquiry with the student's family. Here is a translation of the report of the conversation; it was held in Kirundi, French being only an official language inherited from the colonial times, that is not really spoken by most of the population. Some of the questions and answers may seem strange. A consideration about a woman's pregnancy for example, is immediately followed by the case of the gestation of a cow; it illustrates the importance of cattle in their culture. Also, not everything that was said can scientifically indeed be correct, but that was the way the interview went on.


Fig. 4 Site similar to the place of inquiry

Q. *What about the most visible phenomenon in the sky at night, the moon?*

R. When the moon appeared, the new moon was called *giseruko*. After a few days, when the full moon appeared immediately after sunset, that is, when the moon showed itself completely, the ancestors said the moon did call *back the cattle* (*gucura inka*). When the moon appeared during the night when we did not yet have milked the cattle, it was called that the moon *made the children sleep* (*kuryamika abana*).

Q. *What does the moon look like?*

R. At first, the moon looks like a collar (*ikirezi*) the elderly wear on the neck. Later, the moon becomes bigger, and becomes older, like myself.

Q. *Were there any traditions related to the appearance of the moon?*

R. Yes, there were. When the moon was turned to the left, it meant to the people that something bad would happen to the country: a war, a famine, an epidemic. There was a particular month called *rwirabura* (that is, *the black one*) that corresponded to the month of May. During that month, one could not start the construction of a new house, nor marry, nor practice the sacred *ukubandwa* cult.

Q. *Did one make a link between the rain and the moon?*

R. No! The rain had nothing to do with the moon.

Q. *Long time ago, was there anyone who used bits of strings for counting?*

R. Yes. The use of pieces of strings was particular for counting the number of months during which a woman

was pregnant and to know the number of months of gestation of a cow.

Q. *Then, how did one proceed?*

R. The woman took a string made from a tree of which the elderly made their cloths. Those trees were called *umuhororo* and *umumanda*. Then, the first month a woman knew she was pregnant, she tied the first knot, corresponding to the first month. The second month she tied another knot at the appearance of the moon. At that time, she counted in the same way until the ninth *moon-month* was attained.

It was similar for a cow. Noticing the first signs of fertility, the owner of the cow started tying the first knot, and went on every time the moon appeared, until the total was 10.

Q. *What was done with the strings afterwards?*

R. After having the baby, the woman burned the string, and ate the ashes.

Q. *How did she preserve the string? Where?*

R. She had to bury it for fear of losing it.

Q. *Did someone preserve the string?*

R. No, after delivery, the woman burned the string and ate the ashes!

Q. *And the sun, do you consider it to be a god?*

R. No. The sun was not considered as a god. What was seen as a god was the sheep. Nevertheless, one could not proceed to the cult of the *Kiranga* until after sunset.

Q. *What does the sun represent in the life of a person?*

R. One looks at the sun to know what kind of work to do at a certain time. There were moments to bring the young cattle outside to graze ($\pm$7 a.m., *gusohora inyana*), to bring back the young cattle ($\pm$11 a.m., *gucura inyana*), to bring the cows to drink ($\pm$1 p.m., *kunywesha inka*), to prepare the return of the cattle to the *rugo* in the evening ($\pm$5 p.m.: *amkwaza*). At about 5 a.m., when the birds start singing, we say it is *umutwenzi*: the laughter of the birds.

Q. *And the stars, how do you consider them?*

R. When we woke up early, there was a big star considered as a reference and that we called *shingabuce*, that is, the one that appears to inform about the beginning of the day. As for the rest of the sky, we did not really have any interpretation.

To find confirmation for what was related in this interview, another inquiry was held in *Gitega*, the second city of Burundi. Another student accompanied me to *Gishora*, a hill at about 10 km from *Gitega*. The participants were of very advanced age. We do not reproduce the questions and answers here, but point out a few facts. First, the bright light seen in the morning had another name here. They called it *ndawishinzi*, meaning that someone who wanted to travel had to look at it and leave when it set behind the horizon. The name of *gishingabuce* (cf. above) was less well known. They also talked about a star, they described as *inyenyeri yama iruhande y-ukwezi*, that is a stellar phenomenon close to the moon. It has the name of *umugore-ukwezi* or *the moon's wife*. They affirmed it begins to shine before the moon and that you can even see it before 6 p.m. We suppose that in both cases, the bright "star" could well be Venus, but that it was not realized it is in fact a single star.

In this second interview, the names for the moon were *ukwezi*, and *igihete* corresponded to the new moon, *ingasiro* to the full moon, the first and last quarter having no particular denominations. They could only say that when the moon became larger, it was a good sign (there would be no battles, it would be a good time for harvesting), and in the opposite case, the situation would become worse. They confirmed there were exactly 14 days between 2 phases of the moon. They again did not distinguish any constellations of the stars but a certain group of stars was called *inyenyeri nyinshi* which simply meant *a multitude of stars*. They admired the movement of the stars during the night from the East to the West. For these participants, the sun and the stars were much farther away then the moon, and the sun on its turn was farther then any star. A solar eclipse was called *ubwirakabiri*, that is: a double sunset. In case of a *ubwirakabiri* they believed the sun and the moon waged war against each other.

In order to find out what the words really meant in Kirundi, I had to call for help. Indeed, dictionaries do not really take the scientific meaning of these names into account (just as it is hard to find the mathematical sense of the word *derivative* in an ordinary dictionary). However, biologists have already had more time to find out that for the trees mentioned above, the *umuhororo* corresponds to the *ficus congensis* or *ficus trichopoda* while the *umumanda* is qualified as the *ficus tonninginii* or *ficus ingens*. The University of Burundi disposes of catalogues with the traditional names and the corresponding scientific denominations. A professor in the Physics Department assisted me to find out that *(gi)shingabuce* (which appears to notify the beginning of the day), *ndawishinzi* (which informs travellers of their departure), and even *inyenyeri y' ubuca* (the raising star) are indeed several ways to designate Venus.

Number Counting

G. G. Joseph gives a summary of some different numerical systems throughout the world (see [Gheverghese Joseph, 1992]). The students at the University of Burundi read his explanations about the Yoruba system from Nigeria, with base 20. Expressing 397 as *four hundred minus three* took most of them by surprise. In the beginning, they did not approve the Yoruba method, and preferred the colonial French language for expressing numbers. Yet, when the French expression for that number, *trois cent quatre-vingts dix-sept* (that is: *three hundred and four times twenty and ten and seven*) was actually written on a blackboard, some changed their minds!

A colleague in the mathematics department pointed out to me that the words for large numbers were very remarkable in the country's mother tongues. The Kirundi spoken in Burundi and the Kinyarwanda from Rwanda are two closely related languages. They are rather well structured: a number like 101 is said *ijana na umwe*, meaning word for word *hundred and one*. Another example: 2,110 is *ibihumbi bibili na ijana na icumi* or *thousands two and hundred and ten*.

Their transcription uses a particular punctuation, and there are several declinations (101 can become *ijana na rumwe* or *ijana na imwe*). We will omit these grammatical problems nevertheless since they are not really important for our purposes. There are minor differences between the two tongues; for example: 9,999 in Kirundi: *ibihumbi icenda na amajana icenda na mirongo icenda na icenda* while in Kinyarwanda: *ibihumbi cyenda na magana urwenda na mirongo urwenda na icyenda*, or *thousands nine and hundreds nine and tens nine and nine*.

One can continue analogously above 9,999, but here there is a difference between the actually spoken languages and their traditional form. Today, the above structure is simply extended:

10,000 is	*ibihumbi cumi,*	or *thousands ten;*
100,000	*ibihumbi ijana,*	or *thousands hundred.*

This vocabulary is most probably due to the contacts with the European cultures. Yet, in Kinyarwanda reserved words did exist for these large numbers.

10,000	*inzovu*	*elephant;*
20,000	*inzovu ebyilli*	*elephants two;*
98,780	*inzovu cyenda na ibihumbi munani na magana arindwi na mirongo inani.*	

These words might have been in use at the Royal Court, which received objects from different provinces as a kind of taxes. The administration would then have needed names for numbers up to 10,000.

There seems to have been no need for words larger then 10,000 but they did exist! Some structure can be discovered: diminutives are used to indicate larger and larger names:

100,000	*akayovu*	*a small elephant;*
1,000,000	*agahumbi*	*a small thousand;*
10,000,000	*agahumbagiza*	*a small swarming thousand.*

The translation of the latter is probably not too exact. The sense that we wanted to obtain is: *there are so many things to count that their number is incomprehensible.* Nevertheless, the next multiples of ten have again separate names:

100,000,000	*impyisi*	*a hyena;*
1,000,000,000	*urukwavu*	*a hare.*

Its multiple does not seem to have existed, so here is the largest number that could be formed in the traditional Kinyarwanda:

1,999,999,999 *urukwavu na impyisi cyenda na uduhumbagiza cyenda na uduhumbi cyenda na utuyovu cyenda na inzovu cyenda na ibihumbi cyenda na magana urwenda na mirongo urwenda na icyenda.*

The structure is logical and the words can easily be interpreted: *one hare and nine hyenas and nine small swarming thousands and nine small thousands and nine small elephants and nine elephants and nine thousands and nine hundreds and nine tens and nine.*

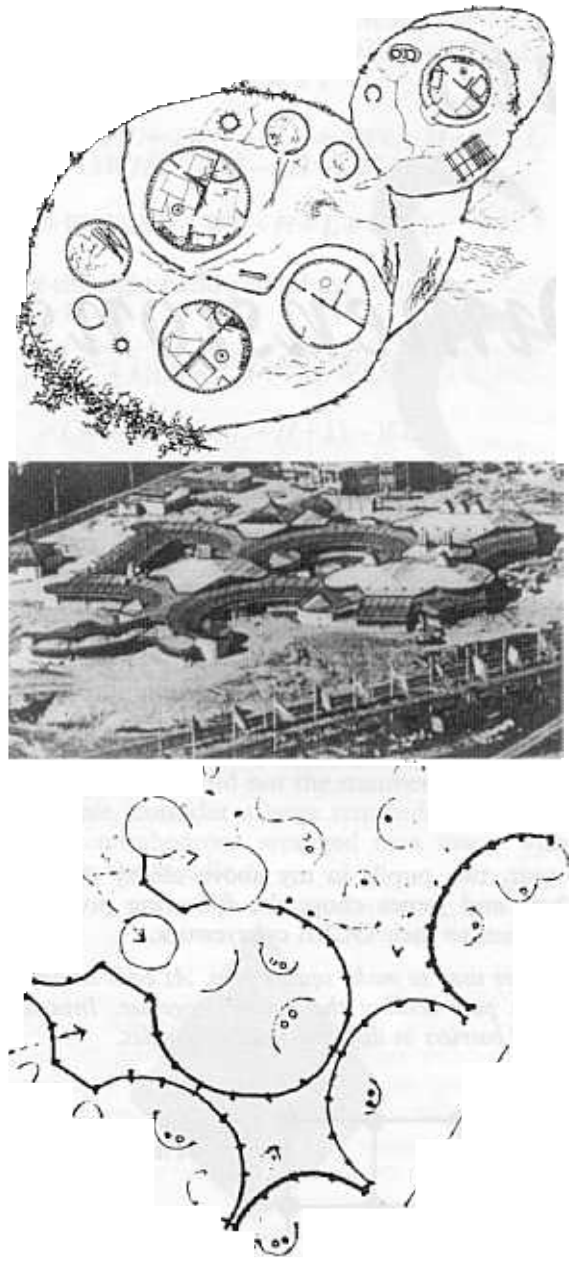
It is hard to imagine whatever the traditional society could have wanted to count by these numbers. It would also be interesting to know how linguists found out about the existence of these numbers and how they do indeed show up in conversations. We found these names and notes on a copied sheet and ignore their exact source.

Today, the youth at the university in Burundi is astonished when they hear about these names for such large numbers. That their own grandparents were capable of this intellectual realization is sometimes met with unbelief. Why did they want to count on and on and try to grasp the *swarm* of infinity?

Notes

The subject is certainly not exhausted. The latter paragraph could have been completed by a study of the different versions of the well known traditional African game played on a wooden board with four rows of holes and several pawns (e.g. beans!). It suggests different conceptions about number systems.

The second topic could have contained information about the role of the sun and the moon in the subdivision of time and a study of traditional calendars. For example, there are indications in a region called the *Moso* (in the Southeast of Burundi), a week traditionally counted 6 days instead of 7, before the arrival of the colonial power. The traditional architecture (section 1) has been studied in detail in [Acquier, 1986]. An additional observation can yet be made. It might seem too romantic to some pure mathematicians and historians (cf. for instance Gardiner, 1992), but we allow us this final diversion. Ptolomee situated the sources of the Nile in the Mountains of the Moon. Some pretend his indications correspond to lake Victoria and the hills that surround it. These mountains stretch out to Rwanda and Burundi, and the most southern source of the Nile is indeed situated in Burundi. Now look at the drawings below. In the first, a plan of a traditional Burundi *rugo* is given (compare to fig. 2); its conception was discussed in the first section. The plan below represents the conference building of the ESTEC (European Space Research and Technology Center). It was designed by Aldo and Hannie van Eyck, and is situated in Noordwijk, Holland. The comparison of the plan of the traditional way of life at the sources of the Nile, and the environment in which Europe's most advanced space researchers evolve, is but a small step (cf. Buchanan et al, 1963). Note this transition from one culture to another is as immediate as the opening scene of Stanley Kubrick's 2001: A Space Odyssey.



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